Sidelobe Suppression of Dipole Antenna Array Using Genetic Algorithm

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ABSTRACT: In this paper, two different dipole antenna arrays are created for suppressing side lobe level. Magnitude of each antenna and distance between each antenna are optimization parameters. GA is used for optimizing magnitude and distance parameter for required side lobe level where phi angle ranges between 40 to 60 degrees, and 60 to 80 degrees. The obtained optimum parameters are used to plot radiation pattern of dipole antenna array using analytical formulation. Furthermore, dipole antenna arrays are created in CST environment and obtained optimum parameters are applied. The radiation pattern of analytical and numerical results are compared and it shows a good agreement where side lobe levels are suppressed. As a result, GA is powerful optimization technique and it can be used for suppressing any given phi angles.

General Terms: Optimization, Antenna Array

Keywords: Dipole Antenna, Antenna Array, Sidelobe Suppression, Genetic Optimization

1. INTRODUCTION

The radiation pattern of antenna array present some unwanted effects such as sidelobe level (SLL). In most antenna array applications, the first SLL is an undesired effect since it causes electromagnetic interference. SLL suppression is active research area in the literature [1,2] for microwave antenna arrays [3].

Particle swarm optimization [4], cuckoo search–chicken swarm optimization [5], hybrid optimization algorithm based on antlion and grasshopper optimization [6], wind driven optimization [7] is used to suppress sidelobe levels of antenna arrays in the literature.

In this study, Genetic Algorithm (GA) is chosen for optimizing parameters such as distance and magnitude for required SLL suppression. First parameter, distance means how far two pair of dipole antenna should be placed considering all antennas are equally fed. Second parameter, magnitude means what magnitude level should feed to each antenna considering all antennas are placed equally.

Furthermore, MATLAB environment is used first to determine the optimum values of distance and magnitude. In this case, dipole antenna array factor is optimized using GA both for distance and magnitude parameter. Later, CST environment is used to construct dipole antenna geometry and obtained optimum parameters are applied to antenna array. The radiation pattern of both analytical and numerical results are compared for the validity of the study.

2. GENETIC ALGORITHM

GA is widely used both for optimization and search technique based on natural selection procedures. The working principle of GA is using population composed of different individuals to evolve for maximizing the fitness function or minimizing the cost function. This method was developed by John Holland (1975), later David Goldberg made this method popular for solving control of gas-pipeline transmission problem. Advantages of using GA are as following:

- Continuous or discrete variable can be used
- Derivative information is not needed
- Capable of dealing numerous variables
- Parallelization is easily realized
- Provide a list of optimum solutions
- Works with variety of data such as experimental, analytical or numerically generated data.

With all these advantages, GA is suitable for SLL suppression of dipole antenna array. First step of creating antenna array is designing unit element. In this case, unit element is a single dipole antenna. The designed dipole antenna can be seen in Figure 1.

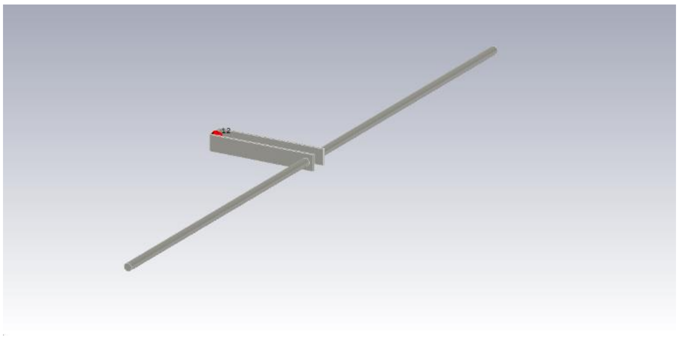


Figure 1: A Single Dipole Antenna

Dipole antenna arrays which has 20 elements are created linearly. In magnitude optimization, the suppression of SLL angle is chosen between 60 to 80 degrees, changing phi values. In this case, the resonance frequency of dipole antenna is selected 0.8 GHz.

2.1 Distance Parameter

In distance optimization, the suppression of SLL angle is chosen between 40 to 60 degrees, changing phi values. In this case, the resonance frequency of dipole antenna is chosen 2.4

GHz. Fitness function that is used for minimizing can be found in the following equation.

$$AF(\varphi) = AF((\varphi)) + 2 * A(n) * cos(\frac{\pi}{2} * (d(n) + p(n)) * cos(\varphi * \frac{\pi}{180}) - cos(\varphi_{max} * \frac{\pi}{180})$$

The above equation is considered as a fitness function and GA algorithm is used to find out the p(n) values for required SLL. In Table 1, the p(n) values are given in terms of lambda (λ). The total distance between each antennas are the sum of d and p values in Table 1. The obtained distances are used in CST enviroment for creating the dipole antenna array which has 20 elements. Dipole antenna array which has 20 element is the sum of two 10 element dipole antenna array that are symetrical on the origin. The radiation pattern of dipole antenna array is also obtained in MATLAB enviroment using optimum distance values.

Table 1. Optimum Distance Parameters

Distance Parameters	
N	10
A	1,1 … 1
d	0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75
p	-0.17, -0.17, -0.43, -0.14, -0.26, -0.15, -0.23, 0.09, 0.15, 0.31
φ	40 … 60 degrees

2.2 Magnitude Parameter

In magnitude optimization, the suppression of SLL angle is chosen between 60 to 80 degrees, changing phi values. In this case, the resonance frequency of dipole antenna is chosen 0.8 GHz. Fitness function that is used for minimizing can be found in the following equation.

$$AF(\varphi) = AF((\varphi)) + 2 * (A(n) + p(n)) * cos(\frac{\pi}{2} * d(n) * cos(\varphi * \frac{\pi}{180}) - cos(\varphi_{max} * \frac{\pi}{180})$$

Where AF : Antenna Factor, n is the number of antennas, φ_{max} is 90 degree, d is the distance 0.5 *λ and p is the result of genetic algorithm in both equations.

The above equation is considered as a fitness function and GA algorithm is used to find out the p(n) values for required SLL.. The obtained magnitude values are used in CST enviroment for creating the dipole antenna array. The radiation pattern of dipole antenna array is also obtained in MATLAB enviroment using optimum magnitude values.

Table 2. Optimum Magnitude Parameters

Magnitude Parameters	
N	10
A	1,1 … 1
d	0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75
p	6.07,2.67,1.35, 9.94,0.76,-0.82,9.03, -0.58,-0.82, 5.01
φ	60 … 80 degrees

3. RESULTS

Radiation pattern of dipole antenna array is plotted with using all parameters in Table 1in Figure 2. In this figure, analytical results and numerical results are compared and it shows a good agreement about SLL where phi ranges between 40 to 60. Moreover, SLL is lower than -20 dB in the figure, which means GA goal is realized. Far field radiation pattern of dipole antenna array is also given in Figure 3.

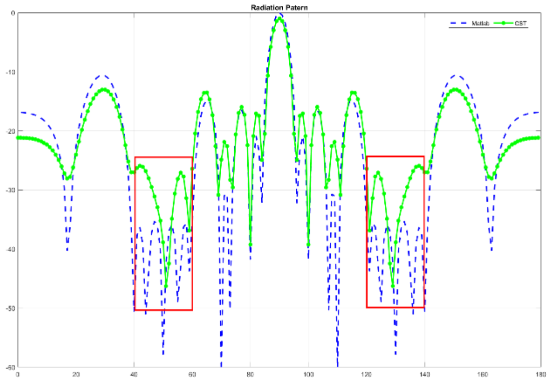
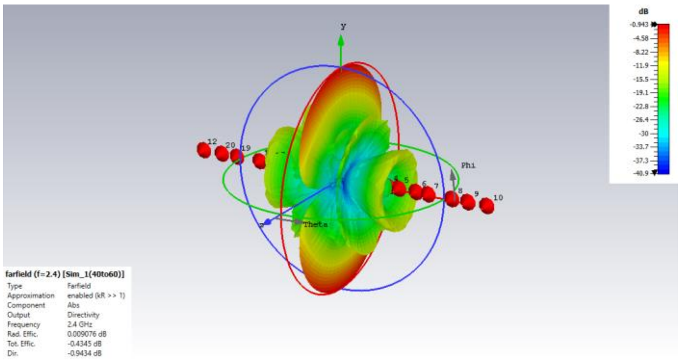


Figure 2: Radiation Pattern of Optimum Distance Parameter



farfield (f=2.4) [Sim_1(40to60)]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Directivity
Frequency	2.4 GHz
Rad. Effic.	0.009076 dB
Tot. Effic.	-0.4345 dB
Dir.	-0.9434 dB

Figure 3: Farfield Radiation Pattern of Optimum Distance Parameter

Radiation pattern of dipole antenna array is plotted with using all parameters in Table 2 in Figure 4. In this figure, analytical results and numerical results are compared and it shows a good agreement about SLL where phi ranges between 60 to 80. Moreover, SLL is lower than -20 dB in the figure, which means GA goal is realized. Far field radiation pattern of dipole antenna array is also given in Figure 5. In this figure, it is clearly visible that after the main lobe, the first SLL is suppressed.

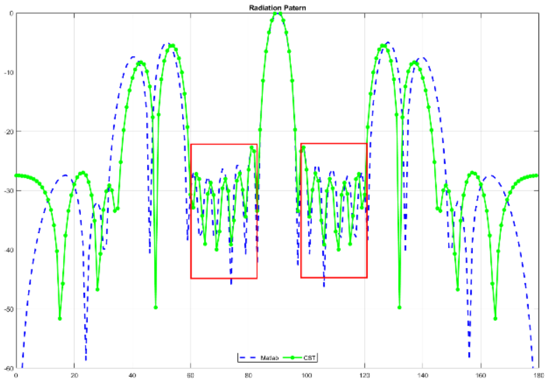
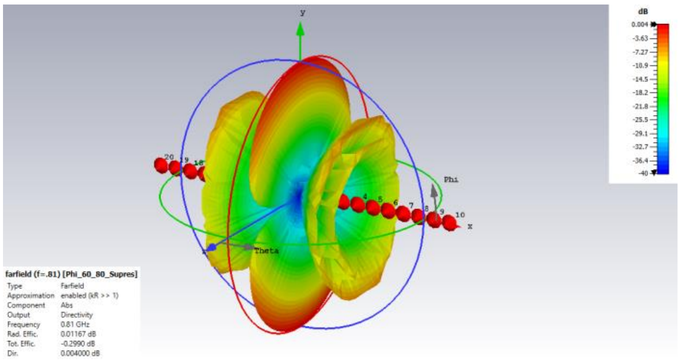


Figure 4: Radiation Pattern of Optimum Magnitude Parameter



farfield (f=.81) [Phi_60_80_Supres]
Type Farfield
Approximation enabled (kR >> 1)
Component Abs
Output Directivity
Frequency 0.81 GHz
Rad. Effic. 0.01167 dB
Tot. Effic. -0.2990 dB
Dir. 0.004000 dB

Figure 5: Farfield Radiation Pattern of Optimum Magnitude Parameter

4. CONCLUSION

In this study, GA algorithm is used for suppressing SLL for two different dipole antenna arrays. Magnitude and distance parameters are optimized for suppressing SLL where phi angles changes between 40 to 60 degrees, and 60 to 80 degrees. GA results are given in Table 1 and Table 2, respectively. Analytical and numerical results of radiation pattern are plotted on the same graph to show the validity of the optimization results. There is minor mismatches in these graphs since analytical approach does not consider of interference between antennas. GA is powerful optimization technique and it can be used for suppressing SLL any given phi angles.

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